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THE CITRUS INSECTS OF TROPICAL ASIA

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INTRODUCTION

In the course of 13 years of investigations upon various biological control problems in the Far East the writer has assembled much information regarding the insect pests of that region. In a previous publication (1)² an account was given of the more important insects attacking citrus in Japan, and further information on this group of pests was included in a recent circular (3) dealing generally with the insects affecting agriculture in that country. This circular deals primarily with those species attacking citrus in the Philippine Islands, Siam, Malaya, the Dutch East Indies, Burma, India, and Ceylon. Although little original information is at hand regarding the species occurring in China, such published records as are available have been included. This has been deemed desirable in view of the fact that that country occupies the intermediate position between Japan and the tropical countries now under consideration.

The writer's investigations have been extensive in Malaya, Java, and Sumatra, but only occasional in China, the Philippine Islands, and India. In none of these countries has a thorough study been made of the insects attacking citrus, and such data as are available regarding the more important pests are contained in a wide range of publications, some of which are not readily accessible outside

¹ These studies were made while the author was working under the general direction of A. C. Baker, in charge of the then existing Division of Tropical, Subtropical, and Ornamental Plant Insects.

² Italic numbers in parentheses refer to Literature Cited, p. 34.

the larger libraries. The greater portion of the published information on this subject is contained in the various reports and memoirs of the Imperial Research Institute and of the provincial departments of agriculture in India, the reports and bulletins of the Departments of Agriculture of Ceylon and the Federated Malay States, the recent book by Dammerman (5) on the agricultural zoology of the Malay Archipelago, and the host-index lists of the more important insects of the Philippine Islands, by Woodworth (25).

CITRUS-PRODUCING AREAS OF TROPICAL AND SUBTROPICAL ASIA

Of the total production of citrus in Asia more is probably grown in the southern half of Japan than in any other one country. In China the producing areas are scattered over a wide region ranging southward and westward from Foochow, being most extensive in the Provinces of Kwangtung and Fukien. In no section is citrus grown in large, solidly planted blocks such as are seen in the United States, but instead is grown in small groves scattered here and there among the fields devoted to other crops.

In the Philippine Islands the different kinds of citrus fruits are grown practically throughout the islands, though commercial production is limited and is largely restricted to the Province of Batangas, on the island of Luzon, which supplies the Manila market.

The growing of citrus in Siam is rather extensive, though largely confined to pummelo (*Citrus grandis*.) This species is able to withstand the wet soil conditions prevailing in the river valleys during the rainy season, and groves in excellent condition have been seen near Bangkok, where the brackish tidewater from the river occasionally rises to within a foot of the base of the tree trunks in the drainage ditches between the rows.

In the Malay Peninsula, comprising the Straits Settlements, the Federated Malay States, the Unfederated Malaya States, and a portion of Siam, only an occasional small grove of orange and pummelo is being grown for commercial production, though these and lime trees are often found as garden trees, particularly in the Chinese settlements.

The more extensive growing of citrus in Java is in well-defined districts, the more important one being the hill section about 50 miles west of Surabaya, including Poenten, Paedgan, and Ngantung. The groves, situated at elevations of from 1,000 to 1,500 feet, comprise a total of approximately 600,000 trees, largely of *C. nobilis* and *C. sinensis*. The second section is that about Garoet, in the west-central part of the island. This is at an elevation of from 2,000 to 2,500 feet, and the plantings total in the neighborhood of 65,000 trees, practically all of which are *C. nobilis*. At Pasar Mingoe, between Batavia and Buitenzorg, and at an elevation of only 500 feet, there are quite extensive areas devoted to the growing of pummelo. There is also a considerable production of citrus on the island of Madura, which lies just off the eastern end of Java. In Sumatra orange and pummelo are grown in the environs of Medan, though the greater production of orange is in the hills or on the plateau areas to the west

of that city and beyond Brastagi. These groves are at an elevation of from 2,500 to 3,500 feet.

In Burma the important producing sections are situated in the hills in the Shan States, in the northeastern part of the country. Here the native varieties of orange are largely grown.

Citrus production is widespread in India, with the main areas in Nagpur, the Bombay Presidency, the Punjab, and southwestern Assam. Garden trees in small numbers may be found throughout the country, both in the plains and in the hill sections up to an elevation of 5,000 feet. In Ceylon the total acreage is relatively small, though groves may be found in the low-lying coastal sections as well as in the hills.

CITRUS-INSECT PROBLEMS IN ASIA AS COMPARED WITH THOSE IN THE UNITED STATES

In the citrus-producing sections of the United States the major insect pests are restricted solely to the homopterous families Coccidae and Aleyrodidae, of which the former is markedly predominant. This situation has arisen as a normal consequence of the establishment of the genus *Citrus* as a commercial crop in this country. The scale insects and aleyrodids, being of relatively small size and often inconspicuous, have gained entry unnoticed into the United States from time to time upon various importations of citrus and other stock from all parts of the world. Even in the early days the more conspicuous pests were eliminated by the importers, whereas the complete removal or destruction of the scale insects was often not accomplished. Thus, as time went on the citrus growers were confronted with an increasing list of major pests of this group. The later importations have often been capable of control by the means already employed against the species established earlier, or by a modification of those methods.

The complete dominance of the situation by this one group of pests, of sap-feeding habit, to the virtual exclusion of all others, is without a counterpart elsewhere. The recent outbreak of the Mediterranean fruit fly in Florida has given some indication of the capabilities of other groups of pests. A considerable number of these other groups, with which we have had no experience in this country, are capable of inflicting equal or greater damage on the crop than that inflicted by those already present.

Among the pests of the fruit itself occurring in Asia there are three groups, each of which is capable, under suitable conditions, of assuming major importance. The noctuid moths of the genera *Othreis*, *Ophideres*, *Calpe*, etc., which suck the ripening fruit of *Citrus* as well as many deciduous trees, can at times inflict great loss. This occurs under both tropical and subtropical conditions, and control is difficult in some cases because of the feeding habits of the larvae, which live on totally different plants. The lepidopterous fruit borer is another pest which as yet is largely unknown as a major pest in the Western Hemisphere and which under favorable conditions causes a complete loss of the crop. The rind borer may also become of major importance. In the United States the fruit

flies have been given rather undue prominence as the outstanding and most destructive enemies against which measures must be directed. The situation abroad, however, does not entirely justify this predominant consideration in comparison with other fruit pests. In all of the countries of tropical Asia the members of this group are of very minor importance, and it is only under the subtropical conditions prevailing in Taiwan (Formosa) that one species assumes a destructive status.

Another general group not as yet represented among the major pests in the United States is that comprising the bark, twig, and trunk borers. Buprestid larvae cause a varying amount of injury to the twigs in all of the tropical countries under consideration. In the Philippine Islands one of these is rated as the leading citrus pest. Other species occur in Malaya, Taiwan, the Dutch East Indies, India, and Ceylon. From the data available it appears that the members of this family which attack citrus prefer a strictly tropical habitat. The cerambycid borers of the branches and trunk are of more general distribution and one or more species is found in each country. While a species may not be present in great numbers, yet a few larvae of certain of these pests are capable of killing the tree, and consequently the actual damage inflicted to the groves may be greater than by many other more conspicuous pests.

The general foliage feeders present no great differences between conditions in Asia and those of the United States, though in the former country there are a much greater number of species, particularly of the Lepidoptera, and the serious damage inflicted by the curculionid beetles is without its counterpart in this country.

The leaf miners, of which only one species is of wide distribution and of such habits as to render it likely to be accidentally introduced, are serious pests. This is particularly true in the case of nursery stock and young field trees. On older trees the infestation of the young foliage may be quite heavy, though the actual, measurable damage may be relatively small.

The life histories and habits of the greater part of the major pests mentioned are such as largely to preclude the possibility of their being introduced into this country, and the present quarantine measures very largely block the usual channels through which the more dangerous pests might otherwise gain entry.

FRUIT FEEDERS

The insects which normally attack the fruit itself, and which are restricted to this portion of the plant for their development, represent only a small part of the species in the following list, the remainder being either general feeders or only incidentally fruit feeders. In the tropical countries those which may be considered as major pests are *Citripestis sagittiferella* in Malaya and the Dutch East Indies, *Prays endocarpa* in those sections and in the Philippine Islands, *Othreis fullonica* (the adults only) in various districts from Japan to India, and *Chaetodacus ferrugineus* var. *dorsalis* in Taiwan.

LIST OF SPECIES ATTACKING THE FRUITS

DIPTERA

Species ³Distribution ⁴

Trypetidae:

* <i>Chaetodacus caudatus</i> Fab-----	Malaya, Dutch East Indies, Burma, India, Ceylon.
<i>Chaetodacus diversus</i> Coq-----	Burma, India, Ceylon.
<i>Chaetodacus ferrugineus</i> Fab-----	Malaya, Dutch East Indies, Burma, India.
* <i>Chaetodacus ferrugineus dorsalis</i> Hendel-----	Taiwan, Philippine Islands, Burma, India, Ceylon.
<i>Monacrostichus citricola</i> Bezzi----	Philippine Islands.

LEPIDOPTERA

Lycanidae:

<i>Virachola isocrates</i> Fab-----	India.
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Noctuidae:

<i>Calpe ophideroides</i> Guen-----	India.
<i>Heliothis obsoleta</i> Fab-----	India.
<i>Ophideres materna</i> L-----	India.
<i>Othreis fullonica</i> L-----	China, Philippine Islands, Malaya, Dutch East Indies, India

Hyponomeutidae:

* <i>Prays citri</i> Mill-----	Philippine Islands, Malaya, India, Ceylon.
<i>Prays endocarpa</i> Meyr-----	Malaya, Dutch East Indies.

Tortricidae:

<i>Cacoecia pensilis</i> Meyr-----	India.
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Eucosmidae:

<i>Argyroplote illepipa</i> Butl-----	India, Ceylon.
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Pyralidae:

<i>Dichocrocis punctiferalis</i> Guen-----	Philippine Islands, China, Taiwan.
* <i>Citripestis sagittiferella</i> Moore----	Malaya, Dutch East Indies.

HEMIPTERA

Pentatomidae:

<i>Cappaea taprobanensis</i> Dall-----	Burma, India.
<i>Rhynchocoris humeralis</i> Thunb-----	China, Taiwan, Burma, India.
<i>Rhynchocoris serrata</i> Don-----	Philippine Islands.
<i>Vitellus orientalis</i> Dist-----	India.

In general the fruit flies of the dipterous family Trypetidae are only minor pests of citrus in the tropical section of Asia. The most common of the species here listed are *Chaetodacus ferrugineus*, its variety *dorsalis*, and *C. caudatus*, which are of very wide distribution. It appears that these fruit flies attain a destructive status only in a subtropical habitat. This is illustrated in the case of *C. ferrugineus dorsalis* (14, 15), which occurs in most of the countries under consideration and in a great variety of fruits other than citrus. To citrus fruit, however, it causes serious and widespread loss only in

³ Those species which are starred have been observed and studied to a varying extent by the writer while the others are included on the basis of published records. In this and the following lists the starred species have been determined by specialists in the various groups on the basis of material collected during these investigations. Practically all Coccidae so marked have been determined by H. Morrison, certain of the Coleoptera by L. L. Buchanan, and several Hemiptera by H. G. Barber. Determinations of *Chaetodacus caudatus*, *Citripestis sagittiferella*, and *Prays endocarpa* were made by H. T. Pagden, of the Department of Agriculture of the Federated Malay States.

⁴ In the distribution records given herewith no attempt has been made to indicate the complete range of the different species, but only those countries are listed in which they have been observed or recorded as attacking citrus. Countries given in italics are those in which observations have been made upon the species by this writer.

Taiwan. In that island it is most abundant in the fruits of pummelo and citron, though all species and varieties are found to be attacked.

The anthomyiid fly *Atherigona excisa* Wied. has been recorded as attacking citrus fruits in Malaya. It is probable, however, that its feeding is confined to decaying rather than sound fruit, and this also undoubtedly applies to the species of *Drosophila*.

Two moth borers of citrus fruits have recently been studied by Pagden (19) in Malaya. The most important of these is *Citripestis sagittiferella*, which has been generally known heretofore under the name of *Crocidomera robusta* Moore. It is known to occur only in Malaya and the Dutch East Indies, and is by far the most injurious of all the insect species which attack citrus fruits in tropical Asia.

It is particularly destructive at the lower elevations, though in Sumatra a few infested pummelo fruits were seen at Kaben Djahé, at an elevation of 4,000 feet, though no trace of it was found in oranges at from 2,500 to 3,000 feet. No indication of this species was found in Siam, and inquiries sent to growers failed to bring out any evidence of attack upon the fruit by this borer or by the fruit flies.

Pummelo is much preferred, though orange, lemon, and lime are also attacked. Upon the first-named fruit the infestation often reaches 100 per cent, and the crop is a total loss. To prevent oviposition the native growers often inclose the fruits in cloth wrappings, the bottom of which may be left open.

The eggs are somewhat scalelike in form and are laid singly or in small clusters upon the surface of the fruit at any stage of growth. The rind is penetrated by the larva shortly after hatching; in the first stage it confines its feeding to this portion of the fruit. After the first molt the pulp is attacked, and the burrow may extend throughout the fruit. This burrow is lined with a silken web, which serves possibly to protect the larva from the fruit juices. One or more holes may be made in the rind by the developing larva to connect the burrow with the open air and to serve as apertures from which the frass and excrement may be thrown out. These holes may be from 2 to 3 millimeters in diameter, and a very large amount of drying sap and excrement may accumulate at these points. This is particularly conspicuous upon pummelo, on which fruit this mass of material may hang for an inch or more from the mouth of the burrow. Where a considerable number of larvae are present in a single fruit these masses give it a very unsightly appearance upon the tree.

During the latter part of the feeding period a noticeable discoloration of the fruit is evident. In the case of heavy infestations the fruits may drop from the tree before feeding by the larvae is complete, but otherwise it may remain after the larvae have left it for pupation, and eventually drop as a result of the decay which soon sets in.

The life cycle from egg to adult covers from 23 to 30 days, of which 5 or 6 days are required for incubation of the egg, from 14 to 19 days for the larval stage, and from 9 to 11 days for the pupal period. There are five larval instars, and pupation takes place within a cell in the soil beneath the tree.

Under the tropical conditions which prevail in the habitat of this species it is evident that a considerable number of generations may

be produced each year. The fact that all kinds of citrus fruits are attacked, and in any stage, reveals a particularly destructive capacity for the species. Fortunately its restricted distribution would seem to indicate that it is adapted only to a very limited range of conditions. Certainly the damage done in its native habitat is comparable to that of the Mediterranean fruit fly (*Ceratitis capitata* Wied.) in the regions most suited to the development of the latter.

In the case of pummelo the bagging of the fruits will protect a considerable part of them from attack, but with the smaller fruits, such as orange, lemon, and lime, this is commercially impracticable because of the cost. Pagden recommends that all damaged fruit be collected and destroyed or placed in emergence cages which will permit of the escape of such parasites as may appear. However, many larvae leave the fruit before it drops from the tree, and consequently this method of control is effective only if the examinations and collections take place frequently enough for detection of the infested fruits before the larvae are mature.

Two species of the hyponomeutid genus *Prays* are recorded from the Far East as pests of citrus, though some confusion prevails as to the identity of the one or more forms present in the different countries.

Prays citri, which has been studied in southern Europe by Quayle (20, p. 22), is strictly a blossom pest in that region, and is not recorded as attacking the growing fruit. The eggs are laid upon the calyx or peduncle of the flower, and the larvae tunnel through the pistil and ovule and feed also upon the calyx and the stamens. Pupation usually occurs within the blossom, though also to a lesser extent upon the leaves and in protected places at the forks of twigs and branches.

In India, Fletcher (6, p. 132) records *P. citri* as feeding in the shoots and the blossom organs, and having general habits identical with those given above for the species in the Mediterranean region.

In the Philippine Islands, San Juan (21) has studied the species attacking citrus fruits there and has published an account of its habits under the same name, *Prays citri*. In these islands it is a serious pest, particularly of orange and pummelo, though all citrus species are attacked. Data are given regarding the percentage of the fruits of each species which was found to be infested. *Citrus sinensis* revealed from 78 to 84 per cent infestation, *C. grandis* from 45 to 83, *C. aurantifolia* from 60 to 68, *C. medica* from 0 to 66, *C. limonia* from 3 to 7, and *C. hystrix* from 0 to 4 per cent. It is thus seen that the lemon is much more lightly attacked than the orange or pummelo. The larvae form galls in the rind and prevent the proper ripening of the fruit, but the blossoms are very rarely attacked. From 20 to 30 galls may be found upon a single fruit. Pupation occurs in crevices in the skin of the fruit and in sheltered places on the leaves and twigs. The immature stages cover from 59 to 76 days, of which from 6 to 12 days are required for incubation of the egg, from 49 to 58 days for the development of the larva, and from 4 to 6 days for the pupal stage.

Pagden (19) gives an account of the habits of *Prays endocarpa* in Malaya. This species is strictly a fruit feeder, and no reference is made to its attacking blossoms at any time. The eggs are laid

singly upon the surface of the fruit, frequently before the petals have fallen. Instead of hatching in the usual manner and crawling about over the surface of the fruit for a time before penetration, the larva bores directly downward through the ventral side of the egg into the rind. The feeding of the larva causes a gall-like swelling to form beneath the point of entry. A considerable mass of lignified tissue is formed, which may extend into the pulp. The surface of the fruit is considerably raised at the points where the galls occur, and such fruits as are heavily infested have a markedly knotty appearance. The larva leaves the fruit at the end of the feeding period and pupates in a loose web in protected places upon the leaves and twigs, and at times upon the fruit itself. The life cycle covers from 4 to 5 weeks, of which incubation requires 4 or 5 days, the larval period about 3 weeks, and the pupal stage from 3 to 7 days.

All species of citrus are attacked, though the heaviest infestations are found upon lemon and pummelo. As many as 84 adults have been reared from a single lemon.

No thoroughly satisfactory means of control has as yet been developed for this species. The eggs are resistant to kerosene emulsion, and the larvae are inaccessible to contact sprays during their entire period of development except for the short time in which they wander about in search for a place in which to pupate. Kerosene emulsion will kill a considerable number of these larvae and of the pupae, but it must be applied frequently because of the overlapping of the generations.

Dammerman (5) records galls of *P. endocarpa* in the rind of various citrus fruits in the Dutch East Indies.

From the data given above it would appear that the Indian form is identical in habit with the *Prays citri* of southern Europe and that the fruit-feeding species in Malaya, the Dutch East Indies, and the Philippine Islands is *P. endocarpa*. Certainly San Juan's account of the supposed *P. citri* in the latter country is very similar to that given by Pagden for *P. endocarpa*, and has little similarity to that of the true *P. citri*. There is, however, a noticeable difference in the degree of infestation of the various citrus species in Malaya and the Philippines, as lemon is the most lightly infested of the common species in the Philippines, whereas in Malaya it is more heavily attacked than either pummelo or orange. The duration of the larval stage, as given by the 2 authors, also shows a considerable difference, as the Philippine form is said to require from 49 to 58 days and the Malayan only 3 weeks.

P. endocarpa is the dominant and most injurious species of the genus in the Malaysian region, and there is apparently some question as to the presence of *P. citri* here.

The fruit-feeding moths of the family Noctuidae are serious pests of citrus in many sections of Asia from Japan to the Dutch East Indies and India. The injury to the ripening fruits results from the feeding punctures made by the barbed mouth parts of the adult moths, which serve as points of entry for organisms of decay, eventually causing the fruits to drop from the trees. (*Ophideres*) *Othreis fullonica* (23), the most injurious of the species listed, is generally distributed throughout tropical and subtropical Asia, and

in some sections of India causes a loss of from 20 to 40 per cent of the crop. It is particularly destructive to pummelo.

The larvae of these moths do not feed upon citrus, and consequently the problem of control is complicated. According to Susainathan (22) those of *Othreis fullonica* are found upon *Cocculus hirsutus* and those of *Ophideres materna* upon *Tinospora cordifolia*. The destruction of these plants in the vicinity of the citrus groves is stated to be an effective means of reducing fruit injury.

A number of species of lepidopterous larvae are recorded as incidental feeders upon citrus fruit in its early stages, though the normal food is the foliage. *Dichocrocis punctiferalis*, which is of general distribution throughout the Asiatic region, is recorded as attacking the young fruit in the Philippine Islands. In Japan (1, p. 10) the larvae burrow through the young fruit and give rise to decay. The more important food plants of this species are the castor-bean, the seeds and stems of which are at times heavily infested, ginger, and the buds of teak. Other plants are also attacked to a less extent.

Argyroplote illepida, which is of wide distribution in the Tropics, is recorded as occasionally attacking the fruit in India and Ceylon. According to Fletcher (6, p. 55) the fruits of litchi are favored by this pest, though even with a heavy infestation the actual damage to the edible portion of the fruit is small. The larvae feed principally upon the stalk and in the seed. This species has also been reared from Cassia, Feronia, and Aegle, and from the pods of Sesbania and Acacia. Pupation takes place in a delicate white cocoon either within the fruits, as in Sesbania and Aegle, or outside it in the case of litchi.

The larvae of *Heliothis obsoleta* are reported as occasionally gnawing the rind of young citrus fruits in India, though the habit is quite exceptional. Those of *Cacoecia pensilis* and *Virachola isocrates* also bore into the young fruit in that country.

Rhynchocoris humeralis is recorded as causing considerable damage to citrus fruits in southern China, Burma, and India, and in the latter country is reported, in conjunction with *Cappaea taprobanensis*, to have completely ruined the orange crop in some sections of the Kumaon district. The injury is brought about by the feeding of the adults upon the fruit, which results in deep punctures, which pave the way for decay. An account has recently been published by Hoffman (9) upon the habits of this species in southern China. The various stages of the insect may be found on the trees from May to November. The winter is passed in the adult stage. The eggs are usually laid on the upper surface of the leaves in clusters of about 14, and 2 or 3 of these batches are deposited by each female. Incubation requires 2 to 9 days, depending upon temperature conditions. The nymphs are gregarious in habit and congregate at the tips of the shoots. There is a single generation each year, and the adults, which emerge in the autumn, have not been observed to mate or deposit eggs during the first season, but do so the following spring.

Injury of a similar nature is also produced by *Vitellus orientalis* in India.

FOLIAGE FEEDERS

The list of insects which feed directly upon the foliage is very large, though few of them inflict sufficient injury to appreciably affect the crop. The curculionid beetle *Hypomeces squamosus* is more general in its distribution and injury than the others listed, and *Papilio demoleus* may be quite destructive in sporadic outbreaks. Both of these are of more importance upon young trees than upon those which are mature. In various sections the grasshoppers of the genus *Cyrtacanthacris* may occasionally become abundant and produce extensive defoliation. No species in this list, however, can be rated as a general major pest.

LIST OF SPECIES ATTACKING THE FOLIAGE *

Species	LEPIDOPTERA	Distribution
Papilionidae:		
<i>Papilio alphenor</i> Cram.....		Philippine Islands.
* <i>Papilio demoleus</i> L.....		China, Taiwan, Malaya, Burma, India.
<i>Papilio helenus</i> L.....		India, Taiwan.
<i>Papilio helenus daksha</i> Hamp.....		India.
<i>Papilio memnon</i> L.....		Indo-China, Malaya, Dutch East Indies, Burma, India.
<i>Papilio pammon</i> L.....		Ceylon.
<i>Papilio polymnestor</i> Cram.....		India.
* <i>Papilio polytes</i> L.....		Indo-China, Taiwan, Malaya, India, Ceylon.
<i>Papilio porinda</i> Moore.....		Ceylon.
<i>Papilio rumanzovia</i> Esch.....		Philippine Islands, Malaya, Dutch East Indies, India.
Lycaenidae:		
<i>Chilades laius</i> Cram.....		Burma, India, Ceylon.
<i>Jamides bochus</i> Cram.....		India.
<i>Tarucus theophrastus</i> Fab.....		India.
Arctiidae:		
* <i>Attacus atlas</i> L.....		Malaya, Dutch East Indies.
<i>Spilosoma metarhoda</i> Wlk.....		Philippine Islands.
Noctuidae:		
<i>Parallelia palumba</i> Guen.....		Malaya.
<i>Tiracola plagiata</i> Wlk.....		China, Taiwan, Malaya.
Lymantriidae:		
<i>Dasychira fusiformis</i> Wlk.....		Ceylon.
<i>Euproctis flavata</i> Cram.....		Philippine Islands.
<i>Euproctis fraterna</i> Moore.....		Ceylon.
<i>Orgyia postica</i> Wlk.....		Philippine Islands, Dutch East Indies.
Lasiocampidae:		
* <i>Suana concolor</i> Wlk.....		Malaya, Dutch East Indies, India.
Psychidae:		
<i>Clania fuscescens</i> Snell.....		Philippine Islands, Celebes, New Guinea.
Limacodidae:		
* <i>Selora nitens</i> Wlk.....		Dutch East Indies.
Pyrallidae:		
<i>Dichocrocis punctiferalis</i> Guen.....		Philippine Islands, China, Taiwan.
Tortricidae:		
<i>Cacoecia epicyrta</i> Meyr.....		India.
<i>Cacoecia isocyrta</i> Meyr.....		Malaya.
Oecophoridae:		
<i>Tonica zizyphi</i> Stain.....		Malaya, India, Ceylon.

* See footnotes to list of species attacking the fruits, p. 5.

	Species	COLEOPTERA	Distribution
Scarabaeidae:			
	<i>Adoretosoma citricola</i> Ohaus	-----	Malaya.
	* <i>Ectinohoplia nitidiventris</i> Arrow	---	India.
	<i>Oxyctenion albopunctata</i> Fab	-----	India.
	* <i>Singhala tenella</i> Blanch	-----	Ceylon.
Chrysomelidae:			
	* <i>Colasposoma aureovittatum</i> Baly	---	India.
	<i>Colasposoma semicostatum</i> Jac	-----	India.
Curculionidae:			
	<i>Astycus chrysoclorus</i> Wied	-----	Malaya.
	<i>Astycus immunitus</i> Wlk	-----	Ceylon.
	* <i>Corigetus</i> sp	-----	Sumatra.
	<i>Episomus figuratus</i> Karsch	-----	Ceylon.
	* <i>Hypomeces squamosus</i> Fab	-----	Malaya, Taiwan, Dutch East Indies, Burma, India.
	* <i>Maleuterpes</i> sp	-----	Java.
	<i>Mylloceris</i> sp	-----	Ceylon.
	* <i>Ottistira</i> sp	-----	Java.
	<i>Peltotrachelus pubes</i> Faust	-----	India.
	<i>Phytoscaphus leporinus</i> Faust	-----	Malaya.
ORTHOPTERA			
Acrididae:			
	<i>Chondracris rosea</i> DeG	-----	Philippine Islands, Malaya, Dutch East Indies, India.
	<i>Valanga nigricornis</i> Burm	-----	Philippine Islands, Malaya. Dutch East Indies, India.
Gryllidae:			
	* <i>Brachytrypes portentosus</i> Licht	---	China, Taiwan, India.

Numerous species of the family Papilionidae, particularly of the genus *Papilio*, are found attacking citrus in all the countries of the Far East, and some of these at times assume the status of major pests. A great many species of this group confine their feeding to the various citrus species and other Rutaceae. They may be found upon practically every tree, though usually not in sufficient numbers to necessitate control measures.

Papilio demoleus is the most destructive of those occurring upon citrus, and in India and Burma is considered to be the worst of all of the leaf-feeding insects attacking this crop. *P. polymnestor* is recorded as being a serious pest in Coorg.

The conspicuous adults of the various species are most active in bright sunlight and deposit their greenish-tinged eggs upon the younger foliage. The larvae are usually conspicuously marked, some of them having a striking resemblance to the excreta of birds. Pupation occurs upon the foliage and twigs. The life cycle is relatively short, and a number of generations may be produced each year.

In those sections where these insects become sufficiently abundant to necessitate control it has been found practicable to collect the eggs and larvae by hand. This is possible through a low labor cost and owing to the fact that the trees are usually much smaller than in the United States, and consequently the uppermost branches are readily accessible.

The lycaenid caterpillar *Chilades larius* is a common though not serious pest of all species of citrus in Ceylon. The larvae feed largely upon the younger foliage.

The atlas moth, *Attacus atlas*, is frequently seen upon citrus in Malaya and the Dutch East Indies, though it is never sufficiently abundant to cause serious injury to the trees. According to Dammerman (5, p. 159), it attacks a wide variety of plants, including mango, guava, and camphor, and on some of these considerable damage is done. This is a very large species, and the larvae, which are greenish in color, attain a length of about 5 inches when mature. Pupation occurs in a brownish-colored cocoon, usually between leaves on the tree. The eggs are often very heavily attacked by a species of *Anastatus*; the tachinid *Tricholyga sorbillans* Wied. parasitizes the larvae and a species of *Xanthopimpla* the pupae.

The larvae of the arctiid moth (*Hyarias*) *Spilosoma metarhoda* (5, p. 164) attack the foliage of citrus and many other fruit trees, and tobacco in the Philippine Islands. They form a silken web over portions of the foliage, and pupation takes place within this web.

Tiracola plagiata (5, p. 170) is recorded from Malaya as attacking lime, though in general the more injurious effect is upon castor-bean, various other plants being merely incidental hosts. The eggs are deposited in clusters on the surface of the leaves. The larvae have the migratory habit, and at times large numbers of them leave the wild growth upon which they have been feeding and attack the various cultivated crops near by. The larva is attacked by the tachinid fly *Blepharipoda ophirica* Wlk.

In Ceylon the larvae of *Euproctis fraterna* do some damage to citrus, though the preferred food plant is *Feronia limonia*. A reduction in injury to citrus is affected by the planting of *Feronia* trees in the groves; these attract the moths away from the citrus. This species occurs also in India but has not been recorded upon citrus there.

Orgyia postica is of wide distribution throughout tropical Asia as a pest of tea, coffee, mango, and other plants, but only in the Dutch East Indies and the Philippine Islands is it known to attack citrus. The females are wingless.

Of the Lasiocampidae the only species on record as attacking any species of citrus in the regions under consideration is *Suana concolor*, which is reported from India. It was frequently seen by the writer in that country and also occasionally in Malaya. In Java it is known to attack avocado and several other fruits. The mature larva attains a length of 4 inches, and the margins of the body bear numerous tufts of long hairs which are held in contact with the surface upon which it rests, and cause it to harmonize markedly with its surroundings.

Various bagworms are found to attack citrus in all tropical regions, and in some instances they have been so abundant as to cause considerable injury to the foliage. *Clania fuscescens* is reported upon citrus in the Philippine Islands.

Setora nitens (5, p. 153) is reported upon pummelo in the Dutch East Indies, though it is of little importance upon this host. Its more serious attack is upon tea and a number of fruit trees and field crops. In Java a very heavy mortality is effected among the larvae by the attack of *Chaetexorista javana* B. and B. This parasite has

recently been introduced into the United States from Japan in an effort to control the oriental moth (*Cnidocampa flavescens* Wlk.).

Tonica zizyphi, which is discussed as a leaf miner, at times causes appreciable injury through the feeding of the larger larvae upon the foliage.

The beetles of several species of Scarabaeidae are known to attack the foliage of citrus. In Ceylon, *Singhala tenella* was seen in fair numbers feeding upon the young foliage of naval oranges and grapefruit in certain of the hill sections. It is also recorded in that island as a pest of tea and various other plants.

Ectinohoplia nitidiventris was found quite abundant feeding upon the newly developed leaves during the early spring in the hill sections of Assam, India.

The two beetle species *Orycetonia albopunctata* and *Colasposoma semicostatum* feed in the adult stage upon the blossoms in India, but rarely in sufficient numbers to affect fruit production. The latter species also attacks the leaves and buds.

In eastern Java there was considerable evidence of scarabaeid injury to the older foliage, which apparently had occurred during the preceding rainy season. At the time of examination, the latter part of October, the beetles were not in evidence.

The curculionid *Hypomeces squamosus* is of general distribution throughout the Dutch East Indies and on the Asiatic mainland from Malaya to India. In Malaya it is the most injurious of all leaf-feeding insects upon citrus. Upon young trees, particularly of pummelo, the beetles assemble in large numbers, and in many of the plantings observed fully half of the foliage had been consumed. A similar condition was noted in Burma in early April, 1930. The adult beetles eat out quite characteristically shaped sections from the edges of the young leaves, and the injury by this species may be readily recognized by the numerous pellets of excrement left upon the leaf surface. Many other plants are attacked in addition to citrus. According to Dammerman (5, p. 95), the larvae of *H. squamosus* are at times found in the young shoots of sugarcane and occasionally in rice.

In western Java two other species of Curculionidae, *Maleuterpes* sp. and *Ottistira* sp., were found in abundance attacking the young foliage. Their feeding may be readily recognized by the presence of small, irregular areas eaten away on the lower surface of the leaves. Species of these two genera, and of *Corigetis* also, were found abundantly upon young foliage at Kaban Djahé, Sumatra.

Of the Orthoptera which attack citrus in tropical Asia, two species are of general distribution from the Philippine Islands to India. These are *Valanga nigricornis* and *Chondracris rosea* (5, p. 129, 132). The first-named species is found largely at the borders of forest areas and attacks such cultivated crops as are grown within 1 or 2 miles of the breeding grounds. The females return to the forest for oviposition. The second species mentioned is known in the Philippine Islands as the citrus locust.

LEAF MINERS

LIST OF SPECIES MINING THE LEAVES*

Species	LEPIDOPTERA	Distribution
Oecophoridae:		
<i>Tonica zizyphi</i> Stain.....	India, Ceylon.	
Lyonetidae:		
* <i>Phyllocnistis citrella</i> Stain.....	General in tropical and subtropical Asia.	

COLEOPTERA

Halticidae:

**Throscoryssa citri* Maulik..... Assam.

Among the leaf miners known to occur upon citrus, only one species is of general distribution throughout Asia. This is the lyonetid moth *Phyllocnistis citrella*, which is often a serious pest of nursery and young orchard trees. Observations in Java have shown it to be more injurious in that island than in any other region in the Far East. Young nursery stock is often killed by the pest when left unprotected, and consequently it is at times necessary to cover the plants with cloth cages during the first two years of growth. At the fruit experiment station in Java it was found that seedlings which were kept covered were ready for budding in 10 months, whereas those that had to withstand the attack of the leaf miner were not of sufficient size before they were 18 or 20 months old.

In localities having distinct wet and dry seasons the greatest injury by this species occurs during the dry season, at which time practically every leaf contains one or more larvae. Relatively few are to be found during the rainy season. This condition is so pronounced that the growth of the tree during the preceding few seasons can be rather accurately gauged by an examination of the foliage. Those sections of the branches bearing leaves with leaf-miner scars developed during the dry seasons, and these alternate with the wet seasons' growths, which show practically no trace of attack. This seasonal development is in accord with the condition existing in Japan, where the greatest damage is done by the first spring generation, which develops prior to the beginning of the rains in the middle of June.

The mines of this species are usually formed upon the undersides of the leaves, though in some tropical sections the majority are on the upper surface. This change of position is probably due to a high atmospheric humidity, and occurs at times when foliage growth is particularly luxuriant. Besides serving as points of entry for citrus canker, these mines cause a curling of the infested leaves, which then provide a shelter for various other insects, particularly the mealybugs, which are thus largely protected from their natural enemies.

Of the various host plants attacked, the favored species is *Citrus nobilis*, whereas the miner occurs very rarely upon *Poncirus trifoliata*. It is recorded upon *Murraya* in India, though extended observations upon several species of this genus in Java and Malaya have failed to reveal a single infested leaf, even where the plants were growing among heavily infested citrus trees. It was noted to be quite common on a species of *Loranthus* growing upon citrus in Siam.

The second lepidopterous miner of citrus here listed is *Tonica zizyphi* (6, p. 108), which occurs in India, Ceylon, and Malaya. This

* See footnotes to list of species attacking the fruits, p. 5.

species is not obligatory in the rôle of a miner during its entire life, but reveals this habit only in the very early larval stage, after which it emerges and adopts the leaf-rolling habit. Pupation takes place within the folded leaf.

A third species of leaf miner was found to occur in Assam, India. The larvae of the halticid beetle *Throscoryssa citri* mine the leaves in large numbers in restricted localities. It is not known to occur outside the above-mentioned Province. The mines may be readily distinguished from those of *Phyllocnistis citri* by the fact that the leaf tissue between the epidermal layers is very largely eaten away, the mine thus being visible from either side, and the excrement forms a distinct and heavy black line down the middle of the mine. Although this mine is serpentine in form, it is never continuous through the entire life of the larva, as the miner has the habit of emerging frequently and later effecting reentry of the leaf at some other point.

A more extended account of *Phyllocnistis citrella* and *Throscoryssa citri* has been presented in a recent publication (2).

SAP FEEDERS

Among the sap feeders recorded upon citrus, those of greatest importance are *Diaphorina citri*, particularly in India and Burma, the scale insects *Lepidosaphes beckii*, *Chionaspis citri*, *Chrysomphalus aurantii*, *Parlatoria ziziphus*, *Pulvinaria polygonata*, and *Coccus viridis* in various sections, and *Aleurocanthus spiniferus* in the Philippine Islands and in some sections of the Dutch East Indies and India. The various aphids also become quite destructive under favorable conditions.

LIST OF SPECIES FEEDING ON THE SAP⁷

Species	HEMIPTERA	Distribution
Pentatomidae:		
<i>Anestlia cruciata</i> Fab.....	India.	
<i>Cappaea taprobanensis</i> Dall.....	Burma, India.	
* <i>Coptosoma cincta</i> Vollenh.....	Malaya, Dutch East Indies.	
<i>Rhynchocoris humeralis</i> Thunb.....	China, Taiwan, Burma, India.	
<i>Tessaratomia papillosa</i> Dru.....	China.	
Coreidae:		
* <i>Anoplocnemis phasiana</i> Fab.....	Malaya, Dutch East Indies, India, Ceylon.	
<i>Leptoglossus membranaceus</i> Fab....	Malaya, India, Ceylon.	
<i>Mictis longicornis</i> Westw.....	Malaya.	
<i>Mictis tenebrosa</i> Fab.....	Malaya.	
<i>Ochrochira rubrotincta</i> Miller.....	Malaya.	
<i>Physomerus grossipes</i> Fab.....	Malaya.	
* <i>Physomerus grossipes oedymerus</i> Burm.	Malaya.	
<i>Riptortus linearis</i> Fab.....	Malaya.	
Miridae:		
<i>Helopeltis collaris</i> Stal.....	Philippine Islands.	
Cercopidae:		
<i>Cosmoscarta funeralis</i> Butl.....	Burma, India.	
Fulgoridae:		
* <i>Lavanus conspersa</i> Wlk.....	Malaya, Dutch East Indies, India.	
Chermidae:		
* <i>Diaphorina citri</i> Kuwayama.....	China, Philippine Islands, Taiwan, Malaya, Dutch East Indies, Burma, India, Ceylon.	

⁷ See footnotes to list of species feeding on the fruits, p. 5.

Species

Distribution

Aphidiidae:

<i>Aphis citricidus</i> Kirk	India, Sumatra, Taiwan.
<i>Aphis gossypii</i> Glov	Philippine Islands, China, Taiwan.
<i>Myzus persicae</i> Sulz	Philippine Islands, Taiwan.
* <i>Toxoptera aurantii</i> Boyer	Philippine Islands, Taiwan, <i>Malaya</i> , Dutch East Indies, India.

Coccidae:

<i>Aspidiotus rapax</i> Comst	Philippine Islands, China.
* <i>Aspidiotus excisus</i> Green	China, <i>Malaya</i> , <i>Java</i> , <i>Sumatra</i> .
* <i>Aspidiotus destructor</i> Sign	<i>Java</i> , <i>Sumatra</i> , India, Ceylon.
* <i>Aspidiotus lataniae</i> Sign	China, <i>Java</i> , <i>Sumatra</i> , India.
* <i>Aspidiotus orientalis</i> Newst	<i>Malaya</i> , <i>Burma</i> , India.
* <i>Aspidiotus palmarum</i> Morg. and Ckll.	China, <i>Malaya</i> , <i>Sumatra</i> .
* <i>Aspidiotus tamarindi</i> Green	<i>Sumatra</i> , India.
* <i>Ceroplastes actiniformis</i> Green	<i>Java</i> .
<i>Ceroplastes ceriferus</i> (Anderson)	China.
* <i>Ceroplastes floridensis</i> Comst	China, <i>Taiwan</i> , <i>Malaya</i> , <i>Java</i> , India.
* <i>Ceroplastes rubens</i> Mask	China, <i>Taiwan</i> , <i>Philippine Islands</i> , <i>Malaya</i> , <i>Java</i> , <i>Sumatra</i> , India, Ceylon.
* <i>Chionaspis citri</i> Comst	China, <i>Malaya</i> , <i>Dutch East Indies</i> .
<i>Chionaspis pusa</i> Green	India.
<i>Chionaspis yanonensis</i> Kuw	China.
* <i>Chrysomphalus aonidum</i> (L.)	China, <i>Taiwan</i> , <i>Philippine Islands</i> , <i>Malaya</i> , <i>Dutch East Indies</i> , India.
* <i>Chrysomphalus aurantii</i> (Mask.)	<i>Philippine Islands</i> , <i>Taiwan</i> , <i>Malaya</i> , <i>Dutch East Indies</i> , <i>Burma</i> , India, Ceylon.
<i>Chrysomphalus aurantii citrinus</i> (Coq.)	China.
<i>Chrysomphalus dictyospermi</i> (Morg.)	Philippine Islands, China.
* <i>Chrysomphalus dictyospermi</i> (Morg.) var.	<i>Sumatra</i> .
<i>Chrysomphalus pedroniformis</i> Ckll. and Rob.	Philippine Islands.
* <i>Coccus bicruciatatus</i> (Green)	<i>Dutch East Indies</i> .
<i>Coccus elongatus</i> (Sign.)	China, <i>Taiwan</i> .
* <i>Coccus hesperidum</i> L.	China, <i>Taiwan</i> , <i>Sumatra</i> , <i>Burma</i> , India.
* <i>Coccus mangiferae</i> (Green)	<i>Sumatra</i> .
* <i>Coccus viridis</i> (Green)	<i>Philippine Islands</i> , <i>Malaya</i> , <i>Dutch East Indies</i> , India, Ceylon.
* <i>Coccus watti</i> (Green)	<i>Malaya</i> .
<i>Crypticerya jacobsoni</i> (Green)	China.
* <i>Crypticerya</i> sp.	<i>Malaya</i> .
<i>Drosicha contrahens</i> Walk	China.
* <i>Fiorinia proboscidea</i> Green	<i>Java</i> , <i>Sumatra</i> , India.
<i>Fiorinia theae</i> Green	China, India.
* <i>Hemichionaspis aspidistrae</i> (Sign.)	China, <i>Philippine Islands</i> , <i>Java</i> , India, Ceylon.
* <i>Hemichionaspis minor</i> (Mask.)	<i>Sumatra</i> , India.
* <i>Howardia biclavata</i> (Comst.)	<i>Java</i> , India, Ceylon.
<i>Icerya aegyptiaca</i> (Dougl.)	China, <i>Taiwan</i> , <i>Philippine Islands</i> , India.
* <i>Icerya pulcher</i> (Leon.)	<i>Siam</i> , <i>Malaya</i> , <i>Sumatra</i> .
<i>Icerya purchasi</i> Mask	China, <i>Taiwan</i> , <i>Malaya</i> , <i>Dutch East Indies</i> , India, Ceylon.
* <i>Icerya seychellarum</i> (Westw.)	China, <i>Taiwan</i> , <i>Philippine Islands</i> , <i>Java</i> , <i>Sumatra</i> , <i>Burma</i> .
* <i>Icerya</i> sp.	<i>Sumatra</i> .
* <i>Lepidosaphes beckii</i> (Newm.)	China, <i>Taiwan</i> , <i>Philippine Islands</i> , <i>Malaya</i> , <i>Dutch East Indies</i> , <i>Burma</i> , Ceylon.
* <i>Lepidosaphes gloverii</i> (Pack.)	China, <i>Taiwan</i> , <i>Philippine Islands</i> , <i>Malaya</i> , <i>Dutch East Indies</i> , <i>Burma</i> .

Species

Distribution

Coccidae—Continued.

<i>Lepidosaphes lasianthi</i> (Green) -----	Philippine Islands.
<i>Morganella longispina</i> (Morg.) -----	China.
<i>Parlatoria oleae</i> (Colvée) -----	China.
* <i>Parlatoria pergandii</i> Comst -----	China, Taiwan, Philippine Islands, Malaya, Burma, Dutch East Indies, India.
* <i>Parlatoria proteus</i> (Curt.) -----	China, Philippine Islands, Malaya, Sumatra.
<i>Parlatoria sinensis</i> Mask -----	China.
* <i>Parlatoria ziziphus</i> (Lucas) -----	China, Taiwan, Philippine Islands, Malaya, Sumatra, Burma, India.
<i>Phenacoccus iceryoides</i> Green -----	India.
* <i>Phenacoccus spinosus</i> Rob -----	Malaya, Dutch East Indies, Burma.
* <i>Platylecanium cribrigerum</i> (Ckll. and Rob.).	Sumatra.
<i>Pseudaonidia</i> (<i>Selenaspidus</i>) <i>articulatus</i> (Morg.).	Philippine Islands, India.
<i>Pseudaonidia duplex</i> (Ckll.) -----	China.
* <i>Pseudaonidia trilobitiformis</i> (Green).	China, Philippine Islands, Java, India, Ceylon.
* <i>Pseudococcus citri</i> Risso -----	China, Taiwan, Malaya, Dutch East Indies, Burma, India, Ceylon.
* <i>Pseudococcus citriculus</i> Green ----	China, Philippine Islands, Malaya, Java, Sumatra, India.
<i>Pseudococcus comstocki</i> (Kuw.) ----	China.
* <i>Pseudococcus filamentosus</i> (Ckll.) -	Malaya, Siam, Burma, Java, Sumatra, Ceylon.
* <i>Pseudococcus kraunhiae</i> (Kuw.) --	China.
<i>Pseudococcus lilacinus</i> Ckll. -----	Philippine Islands, Dutch East Indies.
<i>Pseudococcus maritimus</i> (Ehrh.) ----	China, Java.
* <i>Pseudococcus</i> sp. -----	Sumatra.
* <i>Pseudococcus virgatus</i> (Ckll.) -----	Philippine Islands, Malaya, Java, India.
<i>Pulvinaria aurantii</i> Ckll. -----	China.
* <i>Pulvinaria polygonata</i> Ckll. -----	China, Philippine Islands, Malaya, Java, Sumatra.
<i>Pulvinaria psidii</i> Mask -----	China, Philippine Islands, Dutch East Indies, India.
* <i>Saissetia hemisphaerica</i> (Targ.) ---	China, Taiwan, Philippine Islands, Malaya, Dutch East Indies, India.
* <i>Saissetia oleae</i> (Bern.) -----	China, Taiwan, Malaya, Dutch East Indies, India.
* <i>Tachardina aurantiaca</i> (Ckll.) ----	Siam, Malaya, Java.

Aleyrodidae:

* <i>Aleurocanthus citriperdus</i> Quaint. and Bak.	China, Malaya, Dutch East Indies, Ceylon.
<i>Aleurocanthus incertus</i> Silv. -----	Indo-China.
* <i>Aleurocanthus spiniferus</i> Quaint. --	China, Philippine Islands, Malaya, Dutch East Indies, India.
* <i>Aleurocanthus woglumi</i> Ashby ----	China, Siam, Philippine Islands, Malaya, Dutch East Indies, Burma, India, Ceylon.
<i>Aleurocybotus setiferus</i> Quaint. and Bak.	Java, Ceylon.
* <i>Aleurolobus marlatti</i> Quaint. -----	China, Taiwan, Malaya, Dutch East Indies, India, Burma.
<i>Aleurolobus setigerus</i> Quaint. and Bak.	China.
<i>Aleurolobus subrotundus</i> Silv. -----	China, French Indo-China.
* <i>Asterochiton</i> sp. -----	Malaya, Dutch East Indies.
* <i>Bemisia giffardi</i> Kötinsky -----	Tonkin, Malaya, Dutch East Indies.
* <i>Dialeurodes citri</i> Riley and Howard.	China, Taiwan, Annam, India.
* <i>Dialeurodes citrifolii</i> Morg. -----	Tonkin, Malaya, Dutch East Indies.
<i>Dialeurodes elongata</i> Dozier -----	India.
* <i>Dialeurodes</i> sp. -----	Malaya.
* <i>Dialeurodes</i> sp. -----	Sumatra.

ARACHNIDA

	Species	Distribution
Tetranychidae:		
	<i>Brevipalpus obovatus</i> Donn-----	Ceylon.
	<i>Paratetranychus citri</i> McGregor---	Ceylon.
	<i>Tenuipalpus californicus</i> Banks---	Ceylon.
Eriophyidae:		
	<i>Phyllocoptes oleivorus</i> Ashm-----	Philippine Islands.

Coptosoma cincta (*variegatum* H. S.) has often been observed in large numbers upon citrus foliage in Malaya and Sumatra. Both adults and nymphs are markedly gregarious in habit and may be found in large colonies feeding upon the sap of the young shoots.

Physomerus grossipes is recorded from Malaya as attacking citrus, though in his paper on this species Miller (16) does not count this among the food plants. The eggs, in masses numbering up to 100, are deposited upon the leaves. The female bug remains on guard over the eggs during the period of incubation and for some days after hatching. The young are very gregarious in habit. The nymphal stage covers about 60 days, and the time elapsing from oviposition to the death of the adult is about four months. The more practicable means of control is the collection and destruction of the eggs, nymphs, and adults. The collecting of adults should be done during the early morning hours, at which time they are least active. Kerosene emulsion is an effective spray against the nymphs and adults.

The writer's collections of *Physomerus* upon citrus at Singapore have been determined as *grossipes* var. *oedymerus*. These were very abundant upon the trees, and the conspicuous egg masses were numerous upon the undersides of the leaves.

Anoplocnemis phasiana is occasionally found attacking the young shoots in Malaya and other tropical countries, though it is of very minor importance. *Riptortus linearis* is recorded upon citrus in Malaya, though in Java it feeds almost exclusively upon leguminous plants.

The citrus psylla, *Diaphorina* (*Euphalerus*) *citri*, is distributed generally throughout tropical and subtropical Asia, though it does not assume a destructive status in the Philippine Islands, Malaya, or the Dutch East Indies. According to Husain and Nath (11), who have made an extended study of the species in India, it is of the greatest importance among the insect pests attacking citrus in that country. In the Punjab it is responsible for very serious losses, the injury at times extending to the death of most of the branches and even to that of the trees in entire groves. Complete loss of the crop results several seasons before this final destructive stage is reached. All species of citrus are attacked, and also several related Rutaceae. The damage consists of the withdrawal of large quantities of sap from the tree, the hindrance to the proper functioning of the foliage because of the heavy development of sooty-mold fungus on the surface, and the possible injection of some toxic substance into the tissues. The fruit from infested trees is dry and has a decidedly insipid taste. The first year's attack does not result in a pronounced or lasting injury, though the trees are somewhat weakened, but that of the second year is very destructive, resulting in the killing of a portion of the branches and the production of very little fruit. In case the attack is continued to the third year the death of the trees may ensue.

The eggs are laid upon the young and tender shoots, usually in folds of half-opened leaves, between buds and the stem, and in other similar places. In the case of a heavy infestation these eggs are so numerous as to give a distinct orange coloration to the terminal foliage. The stalk of the egg is embedded in the plant tissue, and thus fixed firmly in position. Oviposition by an individual female extends over a period of approximately one month, and during this time 800 or more eggs may be deposited. The maximum number recorded for one day was 129. In the absence of fresh foliage, oviposition is entirely inhibited. The young nymphs are largely concealed, and feed at the tips of the growing shoots. As growth proceeds, they move down the stem to the older foliage, though in no stage do they feed upon foliage of the preceding year's growth.

All stages are found upon the tree throughout the year. There is no definite hibernation stage, though in northern India development is much retarded during the winter. Some adults may pass the winter in a more or less dormant condition and begin oviposition in the early spring. Those which emerge during relatively warm weather may begin oviposition the same day or very shortly thereafter. In the field activity becomes noticeable at the end of February. Their numbers increase very rapidly during March and April, and it is at this time that the most severe infestations of the year occur. During May and June the insect is largely in the adult stage, and very extended oviposition later takes place upon the new growth induced by the beginning of the rains in the middle of July. There is a numerical decline in October, and relatively few are present during the winter months. Nine generations are produced each year, and there is a considerable overlapping of the different stages.

The nymphs give off a very large amount of honeydew, and when this exudes from the body it is covered with a waxy secretion from the circumanal glands. This thread of coated honeydew may attain some length while still borne by the nymph, but is finally rubbed off or falls off. In the case of very heavy infestations, the ground beneath the tree is white with this material.

The adults are capable of only very limited flight, and movement between leaves or branches is largely accomplished by jumping. Like the nymphs, they feed only upon young foliage.

The duration of the life cycle from egg to adult ranges from 15 to 47 days, depending upon temperature conditions. Incubation of the egg covers from 4 to 6 days in summer and up to 23 days during the winter. The first larval stage requires from 3 to 4 days and, during the colder periods, 11 to 12 days, whereas each of the following stages covers 3 or 4 days. The retardation in development, due to lowered temperature conditions, is therefore much more pronounced in the early stages than in those following. There are five nymphal stages. The life of the adult insect has been known to extend to 189 days.

Six species of parasites have been found to attack *Diaphorina citri* in northern India. The most important of these is *Tetrastichus radiatus* Waterston, and an account of the biology of the species has been presented by Husain and Nath (10). This species is an external parasite upon the nymphal stage only. The egg is de-

posited upon the ventral surface of the body in the groove of the first abdominal segment just behind the posterior coxae. The larva develops in this position and feeds upon the body juices of the host. These parasitized nymphs are active even after considerable feeding by the larva has taken place, but eventually the body cavity is entered and the contents completely consumed. The host body is fastened to the leaf by strands of silk produced by the mature larva, and within this shell pupation takes place. Dead parasitized nymphs may be recognized by the dark-brownish color, which is in strong contrast to the normal orange of healthy individuals. Conspicuous masses of these dead bodies may at times be noted upon the foliage. The mortality effected by *T. radiatus* ranges up to 95 per cent, the higher percentages in general being found during the fall and early winter months. Where *D. citri* is not sufficiently abundant to inflict appreciable damage to the trees, this parasite is said to be the limiting factor responsible for that condition.

Mechanical control measures are very essential in reducing the heavy infestations which develop during the early summer. Various ones of the common contact insecticides are recommended as being effective against this insect. In the case of summer treatment the spray should be applied soon after the young nymphs appear, and winter spraying against the adults is also practicable. If thoroughly applied, this winter spray prevents the usual heavy spring infestation. Cultural methods recommended include proper cultivation to keep the trees in as healthy a condition as possible and the elimination of citrus hedges and other plants upon which the insect may breed, and which consequently serve as reservoirs from which the treated groves may again become infested. It is also important that nursery stock should be kept free from this pest.

The most common of the fulgorids attacking citrus in tropical Asia is *Laccana conspersa*. This species was seen in abundance upon pummelo at Medan, Sumatra, but only occasionally in Malaya. The nymphs are very conspicuous, owing to their heavy covering of white, waxy material, and a considerable quantity of this remains adhering to the leaves, twigs, and smaller branches after maturity has been reached and the adults have moved to other trees. These adults may at times be found assembled in large numbers upon the branches, usually on the undersides. The wings are white, with numerous small brownish spots. Another species of similar habit, though with blackish wings, was also noted in small numbers in Sumatra.

The capsid bug *Helopeltis collaris* is said to attack citrus in the Philippine Islands, though the more common food plant is cacao. Where nymphs and adults are abundant, the death of the affected leaves and shoots occurs.

In the tropical regions in general the aphids are at times very abundant and inflict injury comparable to that which occurs in the citrus-producing sections of the United States. In Java the period of destructiveness is during the early part of the dry season, which extends from May to October.

SCALE INSECTS

Among the monophlebinae Coccidae upon citrus in tropical Asia the well-known genus *Icerya* is represented by a number of species.

In Malaya *I. pulcher* is the dominant form, and at Singapore it was sufficiently abundant on some trees to cause appreciable injury. In addition to citrus, it attacks a considerable variety of ornamental trees and shrubs. At Kuala Lumpur and Bangkok it was frequently seen, though not in large numbers, but it was common on orange at Brastagi, Sumatra. The females are found largely upon the lower sides of the twigs and branches and occasionally upon the leaves.

Iceya seychellarum is of general distribution throughout the Far East, though it was not found in Malaya. It was common in Java and Sumatra. The species is heavily attacked by a species of *Cryptochaetum* and by *Ophelosia crawfordi* Riley,⁸ a considerable number of which may emerge from a single host.

Iceya aegyptiaca is recorded from Japan, China, and India, but was not encountered in the Malaysian region.

The well-known cottony cushion scale, *Iceya purchasi*, is reported by various authors from most of the countries of the Far East. The writer's collections, which have been extensive in Malaya and the Dutch East Indies, have failed to reveal its presence in these sections. A very closely related form which, according to Harold Morrison, may be a variety of *purchasi*, is common at Medan, Brastagi, and at Sinaboen in Sumatra.

An apparently undescribed species of *Crypticerya* was found upon a single orange tree at Kuala Selangor, Federated Malay States. The female scales were largely in crevices in the trunk and larger branches and at the margins of wounds. A considerable percentage showed attack by a species of *Cryptochaetum*.

A considerable number of species of the genus *Coccus* are found upon citrus in tropical Asia. However, the only one of these that ever becomes sufficiently abundant to cause appreciable injury is the so-called green coffee scale, *Coccus viridis*, which is better known for its attacks upon that host than upon the numerous others on which it also is found. This species is found in all of the coffee-producing sections of the world and is one of the major pests of that crop. Its period of great increase occurs during the dry weather, whereas during the rainy season it is very heavily attacked by a fungous disease, and the trees may be almost completely cleared of the scale in a very short time. Those tropical regions which have a reasonably heavy and uniformly distributed rainfall throughout the year are usually free from serious damage by this scale. In the various countries citrus trees may be attacked, though in most instances only a few in the grove are very heavily infested.

An account of the biology of *C. viridis* has recently been presented by Miller (17). The scales of all stages congregate in large numbers upon the foliage and younger branches. The eggs hatch almost immediately after deposition, though in some cases the hatching is delayed for two or three hours. Usually the young larvae prefer the undersides of the leaves, and by far the greater part settle along the midrib and the larger lateral veins. The larvae in any stage, and the mature females as well, are able to change their feeding position at any time, and this habit is very noticeable on branches which, through any cause, have begun to wither. The migration of the scales in

⁸ Determined by A. B. Gahan.

search of fresh foliage takes place very soon after wilting begins, and very few individuals die in their old feeding positions upon such branches. Maturity of the females is attained in from 67 to 69 days in Malaya, so several generations may be produced each season.

Several species of parasites attack *C. viridis* in Malaya, and a large series is recorded in Java. There is, however, no indication that these exert any appreciable check upon the increase of the pest. The percentage of mortality is usually very low, even though the plants may be free from the ants which normally are in attendance upon the scale.

Of the fungous diseases attacking *C. viridis*, a species of *Fusarium* is recorded by Miller from Malaya, while *Cephalosporium lecanii* Zimm., *Empusa lecanii* Zimm., and *Hypocrella reineckiana* P. Henn. are reported to attack this species in Java.

The green coffee scale is exceptionally heavily attended by ants in all of the sections in which it occurs, being in this respect comparable to *Coccus hesperidum* L. In Malaya the dominant species is *Oecophylla smaragdina*, which is discussed elsewhere in this circular. In Java the most important species in this rôle is *Plagiolepis longipes* Jerd. This so-called "gramang" ant has been studied in detail by Van der Goot (7), and some very interesting results have been recorded regarding the actual effect of their attendance upon the scale population. *Plagiolepis* was found to have an unusually favorable effect upon *C. viridis*, the death rate of the latter being much lower, development more rapid, and the progeny much greater in number when attended by the ants. It is believed that the explanation for this condition lies in the acceleration of excretion induced by the stroking of the scales by the ants. The greater excretion promotes more extended feeding, and as a result those individuals which are attended by the ants attain maturity in 65 days as compared with the 83 days required by those which do not receive this attention. A mortality of 39 per cent was found to occur through parasite attack where the ants were absent, while this figure was reduced to 5.7 per cent on the ant-infested trees. In a series of experiments conducted to determine the relation of *Plagiolepis* to the numerical increase of *C. viridis* a series of colonies of known number at the beginning of the test, with and without ants, were again examined four and one-half months later. Upon those plants from which the ants had been excluded an average of 70 scales were present upon the foliage, whereas those infested with ants bore an average of 1,057 individuals.

Field control of the gramang ant is effected by the application of at least 5 pints of carbon disulphide per acre. Numerous short trenches from 8 to 12 inches deep are dug in the grove, and the fallen foliage, which contains most of the ant colonies, is raked into them and covered with soil. The carbon disulphide is introduced among these buried masses of leaves through bamboo tubes extending above the surface of the soil.

Coccus bicruciatatus, which occurs upon citrus in Sumatra, is of interest because of the distinct brownish-colored "halo" which surrounds the larger nymphs and adult females. This material also covers the dorsum of the body. Under the microscope it appears to consist of delicate wax threads, which have apparently been given off

by the scale and have broken and adhered to the surface of the leaf. This halo is not present about parasitized individuals. The individuals of this species occur singly on the leaf and always upon the upper rather than the lower side. In nearly every instance observed the scale was situated at the base of the leaf near its juncture with the petiole, and just to one side of the midrib.

The familiar *C. hesperidum* was noted in several small groves at Kaban Djahé and Medan, Sumatra, though only in very small numbers.

The more or less cosmopolitan black scale of citrus, *Saissetia oleae*, is known to occur in southern China, Taiwan, Malaya, Java, and India. On some ornamentals and wild plants it may become abundant, while only occasional individuals may be found upon citrus. In contrast to this condition, *S. hemisphaerica*, which occurs largely upon ornamentals in the United States, is at times found to infest citrus extensively in the hill sections of Java and Sumatra. In India it is recorded as occasionally being a serious pest upon pummelo in the Konkan, though usually of minor importance. At Malacca, Straits Settlements, where it was abundant upon certain ornamentals, a lepidopterous larva of the genus *Cerynea* was found attacking it in some numbers. The eggs are eaten, and the dead shells of the female scales are incorporated in a case which completely covers the body of the larva. As many as 20 scales may be carried by a single larva, rendering it bulky and conspicuous. The larva may feed upon the scales on either the leaves or the twigs, but pupation occurs on the stem near the point of feeding, and the pupa is inclosed in the case of scales.

Tachardina aurantiaca has been noted upon citrus at Singapore, Malacca, Bangkok, and at several localities in Java. Its distribution in these localities is not general, and usually only a few trees are infested. Upon these, however, several branches may be heavily incrustated with the scale, and the masses of bright reddish-colored male puparia upon the twigs are very conspicuous. At Bangkok it was also seen upon *Loranthus* sp., growing upon pummelo, and was more abundant on this plant than upon the tree itself.

The genus *Ceroplastes* is represented in tropical Asia by four species which feed upon citrus, though none of these is of any consequence as a pest. The red wax scale, *C. rubens*, which has become so destructive in Japan during the last 30 years, can be found in nearly all sections, but only in exceedingly small numbers. The Florida wax scale, *C. floridensis*, is likewise of very general distribution, though occurring in very small numbers. A very large part of the mature scales show evidence of parasite attack. A light infestation of *C. actiniformis* was found upon the twigs and smaller branches of orange at Garoet, Java, and occasional individuals were also seen at Poenten, Bandoeng, and Buitenzorg. This species is also very heavily attacked by parasites. *C. ceriferus* is recorded upon citrus in China, though it much prefers other food plants, and only occasional individuals occur upon the above-mentioned host.

Three species of *Pulvinaria* are recorded upon citrus in tropical and subtropical Asia. The orange *Pulvinaria*, *P. aurantii*, is known from southern China, while the one or more species attacking orange from the Philippine Islands to India have been listed under several names. Heretofore the species which occurs in Malaya and the

Dutch East Indies has been referred to in publications as *P. psidii*, whereas all the material collected by the writer in this region has been determined by Harold Morrison as *P. polygonata*. The Philippine form had also previously been determined as this species.

P. polygonata (*cellulosa* Green) is one of the most important of the coccid pests of citrus, particularly of lime, lemon, and orange, in the Malaysian region. The infestations are often so severe that the trees are black with the sooty-mold fungus which develops upon the honeydew. The nymphal stages are found very largely on the twigs and shoots, but a considerable number of the mature females move to the leaves just before pupation. The white egg masses are very conspicuous upon the leaves, and in a heavy infestation the leaves may be completely covered. In Malaya *Chilocorus melanophthalmus* Muls. was noted in considerable numbers feeding upon this scale. By far the most abundant of the natural enemies, however, was a species of Cecidomyiidae, near *Mycodiplosis*. The adults could be seen in enormous numbers about the infested trees, and many individuals were noted in the act of ovipositing beneath the bodies of the mature females just prior to the formation of the ovisacs. The larvae are evidently predacious upon the eggs. Pupation occurs within the egg sac of the host, and when the time for emergence approaches, the pupa works its way out of the cottony mass until only its posterior portion remains within it. The cast skins remain in this position. A maximum of 12 adults emerged from a single egg mass, and the percentage of these masses which was attacked was very high. The effectiveness, however, of this fly as a controlling factor upon *Pulvinaria* is very questionable, as living eggs were found in every egg mass even after the emergence of a considerable number of the flies.

All *Pulvinaria* in the tropical regions seem to be particularly susceptible to fungous attack. The mortality from this is comparable to that which occurs in the case of *Coccus viridis*. For this reason the heavy infestations are usually of short duration, and the fungus is the most important agency in the natural control of the pest.

The most important of the mealybug species upon citrus is the well-known *Pseudococcus citri*, which occurs practically throughout the world. This species has been observed to become abundant in Malaya and Java, and at times it is present in considerable masses upon the green fruit. The infestations, however, were never general in the groves and were far from being comparable in extent to those which frequently occur in California. The range of food plants attacked by *P. citri* in tropical Asia is very large, and it is known as a very serious pest of coffee in India. In other sections it causes serious injury to many field and orchard crops. It is most destructive during periods of dry weather. The larvae and adults are abundantly attended by ants, though according to Van der Goot (7) the development of the infestation is not influenced by their presence or absence.

Pseudococcus citriculus is often as abundant as the above-mentioned species, though the injury inflicted is not so great, as it lacks the habit of congregating in masses upon the fruit. This species was observed to be very abundant at times at Singapore and Kuala Lumpur and was also seen in smaller numbers in Java. It occurs

most abundantly upon pummelo, and the undersides of the leaves may be completely covered. It also feeds very extensively upon the smaller branches. There was very little evidence of either parasites or predators in these infestations.

Pseudococcus filamentosus was noted in relatively large numbers upon some trees at Singapore and Malacca, and in lesser numbers at Selangor, Federated Malay States, and in Siam, Java, Sumatra, Burma, and Ceylon. These mealybugs assemble in dense masses, usually at the juncture of twigs, at the base of the leaf petiole, and upon the leaves and fruit. The young apparently move very little, and consequently nearly all of the progeny of a single female settle and feed at the same point. In this way rather large and dense masses may be built up, though the number of these upon the tree may be small. In Siam it is attended by large numbers of *Oecophylla smaragdina*.

Pseudococcus virgatus is at times numerous on young trees, particularly on pummelo, and it attacks a wide range of other food plants in the various countries. It was seen in small numbers upon citrus in the Philippine Islands and was quite abundant at Kuala Lumpur, Federated Malay States, and in the hill sections of Java. Feeding is largely confined to the undersides of the leaves. Green has recorded the finding of *Pseudococcus maritimus* in Java, into which island it apparently has been introduced from an unknown source. It is not recorded as attacking citrus there.

Phenacoccus spinosus was found upon orange, pummelo, and lime in Malaya and the Dutch East Indies and was most common at Poenten, in eastern Java, and at Kuala Lumpur and Ipoh, Federated Malay States. It attacks largely the young twigs, the undersides of the leaves, and occasionally the young fruit.

Of the diaspine scales found upon citrus in the Far East, one of the most common is the purple scale, *Lepidosaphes beckii*. In the Malayan region this pest shows a decided preference for pummelo and orange, upon which it was noted to be present in destructive numbers at Singapore and in the hill sections of Sumatra. In some instances the injury was sufficient to cause the death of a portion of the branches. It was frequently seen in all of the citrus-growing sections of Java, though generally not sufficiently abundant to produce noticeable injury. The scales are found upon both sides of the leaves and upon the twigs and branches.

Lepidosaphes gloverii is also of general distribution throughout all of the countries under consideration. It is usually abundant but seldom destructive. It was rare upon pummelo at Bangkok, whereas in some plantings in Malaya the attack was sufficiently severe to cause the death of the smaller branches. In this section it is often abundant upon nursery stock.

Chionaspis (Prontaspis) citri was found to be injurious to pummelo at Singapore. The larger branches and the trunks of the trees were heavily incrustated with the scale. The infested portions of the bark showed on the undersides of the branches a copious exudation of sap, which had congealed in large pendant drops. It is not known positively that *Chionaspis* is directly responsible for this condition, though it was never seen upon uninfested trees. Upon orange at Garoet and Poenten, Java, this species is at times injurious. There

the infestation is confined largely to the leaves and young twigs. On the foliage the scales were present on both sides of the leaves, though they were never numerous on the upper side. This coccid exerts a markedly toxic effect upon the tree, the injury being much greater than the number of scales present would seem to warrant. Leaves which are only lightly infested wither and fall from the tree.

Chionaspis (*Prontaspis*) *yanonensis*, which was introduced into Japan about 25 years ago and has since become exceedingly destructive in that country, is also recorded from China, which is supposed to be its native home. Extended search has failed to reveal its presence in the Malaysian region. This species also has the same pronounced toxic effect upon the tree mentioned above for *C. citri*.

The aspidistra scale, *Hemichionaspis aspidistrae*, is of general distribution, though it has not been seen in destructive numbers. In the Malaysian region it was found only in Java, and was always rare on citrus. *H. minor*, which is recorded from India, was noted in small numbers upon pummelo at Medan, Sumatra.

Fiorinia proboscidaria was found abundant upon a few orange trees at Garoet, Java, though in most of the groves the infestation was light. It was also seen at Medan, Sumatra, and is recorded from India. The long slender scales occur upon the twigs and on the upper sides of the leaves near the midrib.

Seven species of *Parlatoria* are found upon citrus in various sections of tropical Asia. Of these by far the most important are *P. ziziphus* and *P. pergandii*. Both of these at times are very abundant in Malaya, the Philippine Islands, Burma, and India. At Kuala Lumpur a mixed infestation, with *P. pergandii* predominating, almost completely covered the foliage in a small grove of pummelo and caused a pronounced withering of the foliage and complete cessation of growth. In Siam *P. ziziphus* was so abundant upon lime as to cause an extensive dropping of foliage. *P. proteus*, which is of wide distribution, was seen only occasionally, and then in very small numbers. In the more tropical sections all of these species suffer a considerable mortality through the attack of a red fungus, though this is not sufficiently effective to prevent injury to the tree.

The remaining species of *Parlatoria* which are listed as attacking citrus are of very limited distribution and of no consequence as pests. *P. chinensis* was originally described from crab apple, and the single record of its occurrence upon citrus in China is probably accidental. It has not been listed here as attacking citrus.

A large series of species of the genus *Aspidiotus* is found to attack citrus in the Far East, and a number of these were present in destructive numbers in restricted areas. No instance of a generally heavy infestation was seen.

Aspidiotus destructor was observed at Medan, Sumatra, and Bandoeng and Pasar Mingoe, Java. In the latter locality it was very abundant upon a small group of pummelo trees. Apparently the young larvae of this species have very little power of locomotion, or at least it is not exercised, as a leaf usually becomes very heavily infested before the scale can be found upon those adjoining. A portion of the tree may likewise carry a heavy infestation and the remainder be entirely free from it. *Loranthus* sp. growing upon these

trees was also heavily attacked. The exuvium of the female scale is markedly transparent, and the eggs, arranged in a complete circle about the body of the female, can be readily distinguished. On pummelo the scales were largely upon the lower sides of the leaves, and these leaves could be readily recognized from above by the yellowish streak produced by the feeding of the individual scales. On orange at Garoet and Bandoeng both the upper and lower sides of the leaves were infested. In the infestation at Pasar Mingoe a high percentage of the scales were attacked by *Spaniopterus crucifer* Gahan^o and *Aphelinus chrysomphali* Mercet^o, though these were not so abundant in other localities.

Aspidiotus orientalis was seen only once during the course of the investigations in the Malaysian region, and then only in very small numbers upon a single tree at Kuala Selangor, Federated Malay States. Occasional individuals were also found at the experiment station near Rangoon, Burma, on native orange trees brought down from the citrus-growing districts of the Shan States.

Aspidiotus lataniae was noted at Garoet, Java, and at Sinaboen, in the hill section on the east coast of Sumatra. In each case only occasional individuals could be found.

Aspidiotus tamarindi, which has been reported upon citrus in India, was found to be abundant upon several abandoned orange trees at Brastagi and Kaban Djahé, Sumatra. The scales occur on both sides of the leaf. The exuvium is unusually thin, and the eggs and the body of the female are visible through it. In this infestation there was evidence of heavy parasitization.

Aspidiotus excisus was collected at Medan, Sumatra, at Kuala Lumpur, Federated Malay States, and at Poenten, Garoet, and Bandoeng in Java. It occurs upon the branches, twigs, and leaves, and in Malaya and Java is at times sufficiently abundant upon occasional trees to cause some injury.

Aspidiotus palmarum is recorded upon citrus from China, and was seen upon this host at Singapore, Straits Settlements, and at Medan, Sumatra.

The greedy scale, *Aspidiotus rapax*, which in Europe and in some other parts of the world is known as a serious pest, has been reported upon citrus in China and the Philippine Islands. No further records are available regarding its occurrence in other oriental regions.

The California red scale, *Chrysomphalus aurantii*, is one of the most destructive of the scale insects on citrus in the Far East and is of very general distribution. In Malaya it ranks with *Parlatoria pergandii* as among the most important of these pests. Its attack in Malaya and the Dutch East Indies is largely restricted to the younger trees. At Kuala Lumpur the infestation was very heavy upon several plantings of orange trees, and in some instances resulted in the death of the smaller branches. A similar condition was noted at Medan, Sumatra, and Rangoon, Burma. On lemon, even in the case of very severe attack, relatively few scales were found upon the fruit. The species was very abundant on some pummelo trees at Pasar Mingoe, Java, while in the hill sections of that island it was only occasionally encountered. It was noted in Ceylon, but was not at all injurious. In all of the sections the evidence of

^o Determined by A. B. Gahan.

parasite attack was very slight. During the rainy season in the tropics there is a heavy mortality from fungous attack.

The yellow scale, *Chrysomphalus aurantii* var. *citrinus*, is recorded from China, though it has not been seen in any of the countries included in the present investigations.

The Florida red scale, *Chrysomphalus aonidum*, is general in distribution throughout tropical Asia. In Malaya only occasional individuals could be found on the trees. This was also the condition in Java, but in Sumatra a number of orange trees at Kaban Djahé bore a heavy infestation. The scales are situated very largely upon the upper sides of the leaves near the midrib. A considerable portion of the individuals in all infestations showed parasite-emergence holes. In India this species is reported to be a serious pest in the Poona district.

Chrysomphalus dictyospermi is recorded from the Philippine Islands and China. It was not encountered in the Malaysian region, though an unnamed variety was collected upon the upper sides of the leaves of orange at Sinaboén, Sumatra.

Pseudaulonidia trilobitiformis was found occasionally upon pummelo at Poenten and Garoet, Java, though always in very small numbers. The scales were always situated on the upper sides of the leaves along the midrib. *P. duplex*, which has become a serious pest of orange in the Gulf States, is recorded from China, though it is not abundant. In the Asiatic regions this species is much more common on ornamentals than on citrus.

WHITEFLIES

Thirteen species of Aleyrodidae are listed herein as attacking citrus in tropical Asia, and several of these at times become destructive. The most important species is *Aleurocanthus spiniferus*, which may be found in injurious numbers in the Philippine Islands, Sumatra, and China, and at times in India also. In relatively recent years it has become established in southern Japan and has quickly attained the status of a major pest. Specimens from Malaya and Sumatra which have been examined by A. C. Baker appear to differ somewhat in certain characters from the type specimens from Java, which were collected on rose and citrus. At Medan, Sumatra, the infestation on orange and young pummelo trees was often found to be very heavy, though during the rainy season the mortality through fungous attack was very high.

Aleurocanthus citripedus is the species most commonly observed on citrus in Malaya and the Dutch East Indies, and occasionally it becomes very abundant on individual trees, though the infestation is never uniform throughout the grove. Increase is very rapid during periods of dry weather, whereas during the rainy periods the trees are often quickly and completely freed from the pest through a fungous disease.

The citrus blackfly, *Aleurocanthus woglumi*, is of general distribution throughout tropical Asia south of latitude 25° N. On occasional young trees it may become abundant, though the infestation is never of long duration. Unlike the previously mentioned two species of the genus, the greatest increase of *A. woglumi* takes place during

times of high humidity and rainfall, while a heavy mortality occurs during the dry weather. A more extended account of this species is presented in the report dealing with the importation of its natural enemies into Cuba (4). All three species of the genus are heavily attacked by a large series of natural enemies, the most important of which are the internal parasites *Prospaltella divergens* Silv., *P. smithi* Silv., and *Eretmocerus serius* Silv. *A. citriperdus* is also very heavily attacked by *Amitus hesperidum* Silv. in Java and by the variety *variipes* Silv. in the hill sections of Sumatra.

Bemisia giffardi was frequently found in the Dutch East Indies and Malaya, though only in very small numbers. *Asterochiton* sp. was noted in Java, Sumatra, and Malaya, but was common only in eastern Java. In that section the insect was confined almost exclusively to the young fresh foliage of the water sprouts arising from the trunks of the trees. Of the pupae present upon the foliage during October more than 90 per cent showed evidence of attack by *Prospaltella strenua* Silv.

Dialeurodes citri at times becomes abundant upon citrus and other plants in certain sections of India, and occurs also in southern China and Annam. Extended observations have failed to reveal its presence in the Dutch East Indies or Malaya.

At least two apparently undescribed species of *Dialeurodes* occur on citrus in the Dutch East Indies. One of these was found only at Medan, Sumatra, and was restricted very largely to the foliage of pummelo. On some trees, particularly those in sheltered and rather damp places, the infestation was sufficiently heavy to cause appreciable smutting of the leaves. The relatively large adults, the wings of which are slate colored, are very conspicuous when they congregate on the young and tender foliage for feeding. Oviposition, however, is restricted largely to the older leaves.

BARK, TWIG, AND TRUNK BORERS

Among the borers known to attack the citrus trees are a considerable number of species of Coleoptera and two of Lepidoptera. Of those occurring in the strictly tropical sections only one, *Agrilus occipitalis*, can be considered as a major pest, although *Melanauster chinensis*, occurring in Taiwan, China, and Japan, may at times be markedly injurious. Regarding a number of the other species of Cerambycidae there is some doubt as to the actual injury inflicted, as they appear to attack dead or dying trees or branches rather than those in a healthy and growing condition.

LIST OF BORERS¹⁰

COLEOPTERA

Species	Distribution
Cerambycidae:	
<i>Chelidonium cinctum</i> Guér.....	India.
<i>Chloridolum alcmene</i> Thoms.....	India.
<i>Gnatholea eburifera</i> Thoms.....	India, Burma.
* <i>Melanauster chinensis</i> Forst.....	China, Taiwan.
<i>Monochamus versteegi</i> Rits.....	India.
<i>Stromatium barbatum</i> Fab.....	India.

¹⁰ See footnotes to list of species attacking the fruits, p. 5.

	Species	Distribution
Buprestidae:		
	<i>Agrilus grisator</i> Kerr-----	India.
	* <i>Agrilus mediocris</i> Kerr-----	Ceylon.
	<i>Agrilus occipitalis</i> Esch-----	Philippine Islands.
	<i>Chrysochroa fulminans</i> Fab-----	Malaya, Sunda Isl., Philippine Islands.
Scolytidae:		
	<i>Xyleborus affinis</i> Eichh-----	General.
	<i>Xyleborus</i> sp-----	Ceylon.

LEPIDOPTERA

Cossidae:		
	<i>Arbela quadrinotata</i> Wlk-----	India.
	<i>Arbela tetraonis</i> Moore-----	India, Dutch East Indies.

The lime tree borer, *Chelidonium cinctum*, is a serious pest of lime, and of other species of citrus as well, in southern India. Accounts of the life history and methods of control have been published by Murthi (18) and Kunhi Kannan (13). The injury is produced by the boring of the young larvae in the shoots. The adults appear first in late April and persist until early July. Oviposition occurs in late June and early July, the eggs being laid singly on the bark of the young, tender twigs. On hatching, the larva bores into the shoot just below the point of oviposition, cutting a spiral tunnel around it and into the pith. A certain amount of gum exudes from the opening of this tunnel. The twig is easily broken at this point, and wilting very soon occurs. Infested twigs may thus be very readily recognized, and the removal of such wilted twigs is recommended as the most practicable means of control. A single generation is produced each year.

Stromatium barbatum is of common occurrence throughout India as a borer of citrus, and in teak, acacia, mango, and other trees as well. According to Khare (12), however, this species, as well as *Chloridolum alcmene*, is primarily a feeder upon deadwood, and only very exceptionally does it attack live tissue. Pupation occurs in the burrow, and the adult beetles emerge in June and July. The eggs are deposited in cracks in the bark. The total life cycle is said to cover from one and one-half to two years. Thorough removal of dead and dying trees and branches is recommended, and also the painting of wounds and cracks in the trunk and larger branches. As the tunnel is tightly packed with frass it is not possible to kill the larvae by the insertion of sharpened wire into the burrow, or by the injection of volatile poisons.

Chloridolum alcmene is at times found to be abundant. It is found boring in the trunks and larger branches of citrus in the hill sections of southern India and in Assam.

The large cerambycid trunk borer, *Melanauster chinensis*, which occurs commonly in Japan, the coastal sections of China, and in Taiwan, apparently does not extend in range to the tropical sections, as there is no record of it in any of the countries of southern Asia.

The citrus bark miner, *Agrilus occipitalis*, which has been studied by Tan (24), is one of the worst pests of orange and lemon in the Philippine Islands. Heavy attack results in the death of young trees, and the larvae may even penetrate to the roots of dying trees in severe infestations. The eggs are laid in wounds and cracks in the bark of the twigs and branches. These hatch in from 9 to 12 days,

and the larvae mine the bark for from 45 to 60 days. Pupation occurs in the mine, and the adults emerge from 10 to 13 days later. The adult beetles feed at the margins of the leaves and make distinct feeding cuts.

The measures recommended for control are the hand collection of the beetles, the application of a poison spray on the foliage to kill them while feeding, and the painting of the trunk and branches with concentrated lime-sulphur to serve as a deterrent to oviposition. Such branches as show indications of extensive injury should be removed.

The adults of *Agrilus mediocris* were observed in large numbers feeding upon the foliage of citrus, particularly lime, in the hill sections of Ceylon during the latter part of March, and there was abundant evidence of buprestid injury to the twigs and smaller branches. In the plantings examined there was no indication of attack upon pummelo and very little on orange.

Chrysochroa fulminans is primarily a pest of Albizzia and other leguminous trees, but has occasionally been reared from citrus in the Dutch East Indies.

The scolytid *Xyleborus affinis* is recorded as attacking citrus trees, though it is of much more importance upon rubber.

The cossid borer *Arbela tetraonis* is an occasional pest of citrus in the Dutch East Indies (5, p. 72) and in southern India. It is more abundant, however, upon litchi (*Nephilium*), Casuarina, and various other soft-wooded trees. The larva is not a borer in the sense that it feeds exclusively within the stem, but, instead, it makes a tunnel into the stem or branch, preferably at the crotch, and uses this as a shelter during the day. It constructs a long silken gallery, overlaid with fragments of frass and excrement, beneath which it feeds upon the bark during the night. Pupation takes place within the burrow, and the adults emerge in midsummer. There is a single generation each year, and the winter is passed in the intermediate larval stage, though in the more tropical regions in which the species occurs there is naturally little retardation in development.

MISCELLANEOUS CITRUS INSECTS²¹

	HYMENOPTERA	
	Species	Distribution
Formicidae:		
	* <i>Myrmicaria brunnea</i> Saund.....	Ceylon, India, Dutch East Indies.
	* <i>Oecophylla smaragdina</i> Fab.....	General in Tropics.
	* <i>Solenopsis geminata rufa</i> Jerd.....	Malaya.
	COLEOPTERA	
Scarabaeidae:		
	<i>Holotrichia repetita</i> Sharp.....	India.
	ISOPTERA	
	<i>Termes (Cyclotermes) obesus</i> Ramb.	India.

Among the miscellaneous pests of citrus in tropical Asia are several species which at times do considerable damage. The ant *Myrmicaria brunnea* is abundant in the hill sections of Ceylon. When their large subterranean nests occur in plantings of young

²¹ See footnotes to list of species attacking the fruits, p. 5.

trees, considerable damage results through the feeding of the ants upon the sap. They bite away the tips of the buds and assemble in large numbers to feed upon the plant juices which exude from the wounds. They also eat away the surface tissue of the young shoots and make holes in the younger leaves. Appreciable injury occurs only to nursery seedlings, grafts, and young trees in the field, and is at times sufficiently extensive to check growth completely. In a grove of young navel-orange trees about 3 years old a single ant colony inflicted severe injury to a group of 6 trees nearest the nest. A relatively small number of colonies is consequently able to cause much damage in a grove. This species ranks with the lepidopterous leaf miner *Phyllocnistis citrella* as the most injurious of the pests attacking young trees in the hill sections. It is also recorded as injuring the foliage of garden plants in southern India.

Throughout practically all of the tropical regions of Asia the large red ant *Oecophylla smaragdina* is found in large colonies in various trees. Upon citrus a considerable mass of foliage may go to make up the nest, and each tree may contain several of these. The ants are especially abundant on trees infested with scale insects, particularly *Coccus viridis* and others of that genus, *Pseudococcus* spp., and *Pulvinaria*. The actual damage to the tree through the presence of these ant colonies is small, possibly none at all; but their presence upon the trees makes the picking of the fruit exceedingly difficult, as the ants are very pugnacious, and the bite is painful.

The fact that these ants foster various scale insects, some of which are destructive, offsets to a considerable extent the presumed benefits resulting from the destruction of lepidopterous larvae. It is, however, conceivable that an appreciable degree of protection from boring insects may be secured through the prevention of their oviposition. The readiness of the ants to attack any of the larger insects which settle upon the tree, and drive them away, may very possibly effect a reduction in the number of eggs deposited upon these trees. Injury by the feeding of adult beetles and grasshoppers may also be reduced for the same reason.

An account of utilization of *Oecophylla smaragdina* in the control of foliage-feeding insects of citrus in southern China is given by Groff and Howard (8). According to these writers, the ants are regularly colonized in the groves in that region, and the growers insist that benefits accrue from this practice. The nests are collected during the winter while the ants are inactive and are transported to the new groves and placed in the trees. The larger branches are banded to prevent the escape of the ants and to confine their feeding to these particular trees. In the spring the adults emerge from the hibernation nest and build another from fresh foliage. Bamboo slats are then slung from tree to tree to permit of more extended foraging. As sufficient insect food material is not available in the trees during the early spring months to maintain the colony, they are regularly fed during this period.

A third ant species, *Solenopsis geminata rufa* Jerd., was found to cause some injury to young pummelo trees in several groves in Malaya. Normally this species feeds upon the exudations of aphids and various soft scales, but during periods of dry weather, when

this food supply is insufficient, they have been known to eat away the surface tissue of the young shoots, which results in the death of the terminal portions. They also eat the lower epidermis of both young and mature leaves, and where this comprises more than half the total under surface the leaf withers and falls.

The grubs of *Holotrichia repetita* are recorded as feeding at the roots of citrus trees in India

A twig and leaf gall, produced by an undetermined agency, was observed to be very abundant upon lime at Bandoeng, Java. All of the infested trees were situated in damp and shaded places, while others in more normal situations were free from attack. The galls were irregularly spherical and from 3 to 5 millimeters in diameter. Examination at the time of collection led to the belief that these galls were of cecidomyiid origin, and many showed numerous emergence holes. However, a small number of adult beetles and larvae were present in the galls. The adults have been examined by W. S. Fisher and the larvae by A. G. Boving, and have been determined as a species of *Corylophus* of the family Anisotomidae. The exact relation of this species to the gall is unknown.

SUMMARY

Approximately 200 species of insects are listed as attacking citrus in tropical Asia. By far the greater part of these are scale insects, though these do not occupy the dominant position which they hold in the United States.

The enemies of the fruit itself include a series of fruit flies of the dipterous family Trypetidae, two lepidopterous borers, and a number of noctuid moths, the adults of which suck the juice of the ripening fruits. The fruit flies are of minor importance in the Tropics, and only one species is recorded as assuming a destructive status, this being *Chaetodacus ferrugineus* var. *dorsalis* under the subtropical conditions of Taiwan. The larger lepidopterous fruit borer *Citripestis sagittiferella* is exceedingly destructive but limited in distribution.

The most important of the foliage feeders is the curculionid beetle *Hypomeces squamosus*, which is of general occurrence throughout the Tropics. Others may be of equal importance in more limited areas.

Three species of leaf miners are known, of which two are important and only one, *Phyllocnistis citrella*, of general distribution throughout all of the citrus-producing countries of Asia.

Among the scale insects no one species is present in a uniform and destructive status over a large area. The more injurious species are *Lepidosaphes beckii*, *Chionaspis citri*, *Parlatoria ziziphus*, *Chrysomphalus aurantii*, *Pulvinaria polygonata*, and *Coccus viridis*. *Chrysomphalus aurantii* and *Parlatoria ziziphus* are heavily attacked by fungus, though not controlled, whereas *Pulvinaria polygonata* and *Coccus viridis* are at times completely wiped out through this agency.

Among the aleyrodid species, *Aleurocanthus spiniferus* is at times destructive in the Philippine Islands, Sumatra, China, and India, and is one of the major pests in southern Japan. *A. citriperdus* occasionally becomes very abundant in Malaya and the Dutch East

Indies but is periodically controlled by fungus attack. *A. woglumi* is a very minor pest in all the countries of tropical Asia.

Of the bark, twig, and trunk borers, *Agribius occipitalis* is ranked as a major pest in the Philippine Islands, and some one of this family is found in every tropical country. *Melanauster chinensis*, the injurious trunk borer of China, Taiwan, and Japan, does not extend into the strictly tropical regions. In the case of a number of the remaining Cerambycidae listed there is some question as to whether they attack living trees or breed more largely in dead branches and in trees which have been weakened by other agencies.

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